

Erni (Henry)

A SYSTEMATIC OUTLINE

FOR THE

QUALITATIVE ANALYSIS OF URINE.

BY

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WITH TWO ILLUSTRATIVE LITHOGRAPHIC PLATES.

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# QUALITATIVE ANALYSIS OF URINE.

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THE following systematic directions for the qualitative analysis of urine are intended to comprise a progressive series of chemical and microscopical tests. They are mainly compiled and condensed from the works of Bird, Lehmann, Gmelin, etc., but particularly from Neubauer's admirable "Anleitung zur Analyse des Harns," which has rapidly passed through three editions. The illustrations are copies from Funke's celebrated "Atlas der Physiologischen Chemie."

An article on the same subject was published by us several years ago in the *Peninsular and Independent Journal*; it was brief and incomplete, but, such as it was, formed the nucleus of the present essay.

The urine may be regarded as the recipient of such substances as, entering into the general circulation, are not required for the nutrition of the body, and hence are secreted by the kidneys, partly in their original form, and partly as products of direct or retrograde metamorphosis of matter.

The composition of urine being thus dependent upon the nature of our

food, as also upon the normal or the abnormal condition of our organism, must vary considerably in its physical and chemical qualities, giving us, nevertheless, a correct though reflex image of the functional activity carried on in our body at different times.

In the solid excrements we find, besides the incombustible or partially oxydized organic parts of our food, all the less soluble or insoluble mineral salts contained therein.

Liebig thus compares the fæces with the soot and ashes of a common fire. He proved by experiment that albuminous compounds, when partially oxydized by fusion with potassa, yield on the subsequent addition of an acid, volatile bodies, possessing the peculiar odors which characterize excrementitious matter.

#### CHEMICAL AND PHYSICAL CHARACTER OF THE URINE.

Fresh normal urine is of a light amber color, of a bitter saline taste, and exhibits a peculiar (varying) odor. Its specific gravity never exceeds 1.03. The acid reaction of healthy urine is due, according to Liebig, to the presence of acid phosphate of soda =  $(\text{NaO}, 2 \text{HO}) \text{PO}_5$ , which, dissolving uric and hippuric acids, gives rise to an acid solution, as can be shown by mixing these constituents artificially in proper quantities. Fresh urine, from which the mucus has been filtered off, keeps unaltered for a long time, whilst without this precaution it is speedily decomposed, the mucus acting, according to Scherer, as a ferment upon the extractive coloring matter, lactic and acetic acids being thereby formed, which, whilst they increase the acidity of the urine, occasion chemical reactions with the more soluble urates, producing acid salts, besides precipitating free uric acid. Oxalate of lime may likewise be traced at this time, (*acid fermentation*.)

After a while the urine turns neutral, and then alkaline; it becomes paler, is covered with an iridescent film, and emits a putrid smell; the urea has been decomposed into carbonate of ammonia. The crystals of uric acid (more or less colored) in the sediment have now disappeared, and their place been filled with white granules of urate of ammonia, another portion of ammonia combining with the phosphate of magnesia in the urine, forms large regular crystals of insoluble triple phosphate of magnesia and ammonia, (*alkaline fermentation*.)

We must distinguish at least three distinct and peculiar varieties of normal urine secreted at different times, and under different influences, by the same individual.

1. *Urina potus*, i. e., urine passed shortly after partaking of copious drinks, is pale, and of low specific gravity, (1.003—1.009.)

2. *Urina cibi, i. e.*, urine secreted not long after digestion of a regular meal differs considerably in its physical character; specific gravity, 1.020—1.030.

3. *Urina sanguinis, i. e.*, morning urine, passed after rising from bed, is of medium density, 1.015—1.025.

This urine, comprising all its essential properties, is most suitable for a chemical analysis.

## I. COMPOSITION OF NORMAL URINE.

### (A) *Organic Products.*

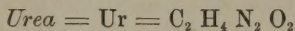
Urea, uric acid, kreatine, kreatinine, hippuric acid, odoriferous and coloring matter, together with mucus of the bladder and epithelium, derived from the urinary passages.

### (B) *Inorganic Constituents.*

Sulphates and phosphates of the alkalis and alkaline earths, chloride of sodium, and traces of iron and silica.

These several ingredients we shall consider separately, but very briefly, and next treat of the abnormal substances, which are both soluble and sedimentary.

### (A) ORGANIC CONSTITUENTS.



Urea constitutes the principal ingredient, dissolved in urine of man, varying between 0.5 to 5 per cent.; it is also found in the urine of all animals.

It must be looked upon as the final product of the destructive assimilation of tissues; by it the greater portion of ejected nitrogen is carried in a neutral form (not affecting the urinary passages as, for instance, ammonia would) out of the system.

The amount of nitrogen thus eliminated covers about two-thirds of the whole quantity of that element introduced into our system, (Bischoff,\*) another portion of nitrogen being probably thrown off by the skin and lungs; indeed, Wiederhold† was enabled to trace uric acid, urate of ammonia, common salt, together with adhering yellowish-red pigment in the lung exhalations of young and healthy persons. *Ur* may be artificially prepared from cyanate of ammonia, both having an equal per centage composition. Permanganate of potassa, by its oxydizing agency upon

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\* Gmelin's Handbuch, (Zoo-chemie by Lehmann,) 1857, p. 319.

† Deutsche Klinik and Varges Zeitsch., f. Med. 1859.

protein compounds, yields *ur*; it is of great chemical stability, passing unchanged through the organism. Heated with mineral acids or alkalis, it takes up 2 eq. of water, forming carbonate of ammonia; this conversion is also effected by animal matter in a state of decomposition, (pigment of urine.) It forms, with acids, regular salts.

Important to us are the nitrate and oxalate. From the latter urea can be isolated by means of carbonate of lime or baryta; we extract it by alcohol, and evaporate when it crystallizes in four-sided prisms, soluble in cold and hot water.

URIC ACID, (lithic acid,)  $\text{ur} = \text{C}_5 \text{H}_2 \text{N}_2 \text{O}_3$

This acid, closely allied with urea, is likewise a product of decomposition of nitrogenous organic compounds. In a normal condition the organism secretes but a small portion; it appears that *ur*, dissolved in the blood, is further decomposed into carbonic acid and urea. We find a proof of this in the fact that if *ur* be swallowed, it undergoes the same change in the organism, passing off as urea into the urine, and exhibiting just the same deportment when acted upon by oxydizing substances, peroxide of lead and permanganate of potassa. Both substances, *ur* and *ur*, seem to balance each other; for where we have an increase of *ur*, we find the amount of urea lessened. In functional disturbances of circulation and respiration, more *ur* is secreted, which we find accompanied usually by oxalate of lime.

Guanine (found in guano) and kreatine, when taken into the organism, yield urea and carbonic acid; when acted on by permanganate of potassa, kreatine produces oxalic acid, etc.; guanine, oxalic acid with urea.

Uric acid, kreatine, and guanine, then yield, upon an incomplete oxydation, oxalic acid as a final product.

Uric acid, in contact with yeast cells, is transformed into urea and oxalic acid, (Ranke.\*)

But though guanine, kreatine, urea, and uric acid, are physiologically closely related, their chemical connection is not yet fully understood. Crystals of free uric acid never occur in fresh urine, (except in some acute inflammatory disorders,) and are the result of acid fermentation, which takes place by standing, (very rarely in the bladder itself.) The lactic acid produced in this process, and acting upon the urate of soda in the urine, throws down *ur*, with more or less pigment, (Lehmann.†) The shape of the crystals varies, forming sometimes rhombic plates, but more frequently figures like a whetstone, the broad sides of which often

\* Canstatt's Jahresbericht. Würzburg, 1859.

† Lehmann, Handbuch d. Physiol. Chemie. Leipzig, 1854, p. 54.

adhere together, (see fig. 14;) should there be any doubt as to the character of the crystals, we dissolve them in liquor potassae on the object-glass, adding subsequently a drop of chlorohydric acid, and reëxamine the crystals formed, under the microscope. A variety of these may be obtained by treating normal urine with chlorohydric acid. In larger quantity uric acid is generally prepared from the urine of birds (guano) and of reptiles, (snakes,) containing an abundance of it.

In urinary calculi it forms most frequently the nucleus or central portion.

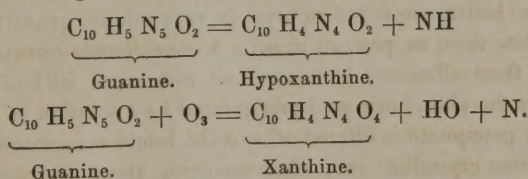
Uric acid and its salts are easily recognized chemically. By evaporating them with some nitric acid at a gentle heat, there remains a pink-colored mass, which, moistened with ammonia, turns to a lively red, (formation of murexide,) and when subsequently submitted to the effects of potassa, violet.

In most intimate chemical relation with uric acid are the following three bodies, which might be but different degrees of oxides of the same radical;\* it is probable that all these occur in urine of man; there is, however, some doubt yet as to guanine.†

1. Hypoxanthine, (sarkine) =  $C_5 H_2 N_2 O$ .

2. Xanthine, (xanthic oxide or uric oxide) =  $C_5 H_2 N_2 O_2$ . These bodies have been actually traced in urine, but are more commonly found in calculi.

3. Guanine =  $C_{10} H_5 N_5 O_2$  is directly allied to the former two bodies, and has been converted into xanthine, (Strecker.‡) It forms a normal constituent of the pancreas, together with xanthine and leucine.§ By doubling the formulas of xanthine and hypoxanthine, the resemblance of these products to guanine is rendered obvious.



\* See Nashville Medical Record, Aug., 1859; also G. Bird, pp. 163-66.

† It has been found in urine of spiders, river crawfish, etc. Strahl and Lieberkühn traced it in human urine, and Scherer found it to constitute a normal part of the pancreas.

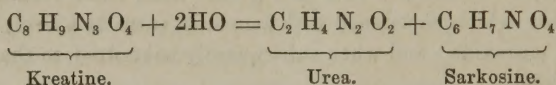
‡ Verwandlung des Guanins in Xanthin von Strecker in Annalen d. Ch. and Pharm. Bd. cviii. pp. 141-156, and Chem. Central Blatt, 1859. No. 9, pp. 134-38.

§ Leucine =  $C_{12} H_{13} N O_4$  has also been traced in urine, and appears to be a product of retrogressive metamorphosis of animal tissues.

Guanine, xanthine, and hypoxanthine, evaporated together with nitric acid, leave a yellow residue, changing into a fiery red by potassa.

Kreatine =  $C_8 H_7 N_3 O_2$  and kreatinine =  $C_8 H_9 N_3 O_4 + 2HO$ .

These bodies occur in small quantities in urine, and are no doubt to be regarded as products of decomposition of nitrogenized worn-out structures, and probably derived from a certain class of these, (muscular structures.) The kreatine, when pure, forms colorless, transparent crystals of the klino-rhombic system, (see fig. 6;) it is soluble in hot water, with difficulty in alcohol, and insoluble in ether. Boiled with caustic baryta, kreatine is decomposed into urea and sarkosine.



If the action continues longer, the urea resolves into ammonia and carbonic acid; taken artificially into the organism, it becomes converted into urea. Chloride of zinc does not precipitate pure kreatine; weak acids dissolve kreatine unaltered, but if boiled with concentrated acids, and evaporated at a low heat, it loses 2 eq. of water, and is converted into a new body, kreatinine, which is strongly basic, driving out ammonia from the salts of the latter; it is easily soluble in cold water, but insoluble in cold alcohol; is not thrown down by chloride of zinc, and crystallizes in the monoclinic system, (see fig. 7.)

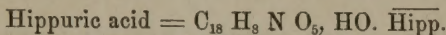
Under certain circumstances the kreatinine (by taking up 2 eq. of water) is again transformed into kreatine, and it would appear from recent experiments by Liebig,\* that kreatine is a secondary product of the decomposition of kreatinine.

Both these bodies are found in urine in very minute quantities, and in order to isolate them we proceed thus: A considerable quantity of fresh urine (free from albumen) is neutralized with some milk of lime, and subsequently the phosphoric acid precipitated by a solution of chloride of calcium, the precipitate is filtered off and the liquid evaporated, until the salts in solution crystallize out; after removing these, the mother-liquor is mixed with a very concentrated (syrupy) solution of chloride of zinc. After the lapse of a few days, groups of yellow crystals are formed, which are a combination of kreatinine and kreatin with zinc. They are first washed with cold, and then dissolved in hot water. By adding now hydrated oxide of lead, we throw down the zinc, as well as the chlorohydric acid which were held in solution.

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\* Nashville Medical Record, Oct., 1859, p. 119.

The liquid, filtered off, is boiled with animal charcoal, and after the removal of the latter, evaporated to dryness. The residue is treated with boiling alcohol in which kreatinine is insoluble, whilst kreatine remains behind; (a small portion separates from the solution as it grows cold.) When the alcoholic solution is boiled down, the kreatinine is obtained pure in crystals.



This acid is found largely in the urine of herbivorous animals, and in very minute quantities in that of man, (0.15 per cent. average of twenty-six analyses,) increasing or decreasing according to the prevalence of vegetable or animal food taken into the system; but\* as its formation does not appear to depend upon any one vegetable substance (and no benzoic acid could be traced in any) consumed by herbivora, and since it is never entirely absent in the urine of man, even when living for some time exclusively upon animal diet, we are justified in pronouncing it to be probably a product of retrogressive metamorphosis of nitrogenous tissues.†

It occurs in increased quantity in diabetic and febrile urine. In urine which is not quite fresh we find it usually converted into benzoic acid, which upon evaporation volatilizes with the vapor; on the other hand, by swallowing benzoic acid, we find it in the urine converted into hippuric. To detect the presence of an abnormal proportion of hippuric acid, we evaporate the urine over a lamp, to a small bulk, add chlorohydric acid, and set the mixture aside for twenty-four hours; the acid crystallizes in rhombic needles, frequently aggregating into fan-shaped bunches of crystals, (see fig. 4;) these may be tested chemically, provided there is sufficient material to operate upon. Hippuric acid could perhaps only be confounded with benzoic acid, sometimes found in urine, which latter, at a higher temperature, volatilizes, however, in white, dense fumes, without undergoing decomposition, while the former, when heated dry in a small glass tube, shows the following reaction:

1. It melts and yields a sublimate of benzoic acid, benzoate of ammonia, and a red, oily matter, which has a very fragrant odor like that of tonka bean, solidifies again on cooling, and at a still higher temperature

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\* Weissmann and Hallwachs über den Ursprung der Hippursäure in Canstatt's Jahresbericht, 1859. (Leistungen der Physiologie, v. Valentin, pp. 72, 73.)

† According to Roussin, (ibid., p. 198,) well-nourished horses secrete when at rest scarcely any hipp., but much urea; by strong exertion of the animal the reverse takes place; we might hence assume hipp. to be a product of oxydation of urea, but this is opposed to known facts.

gives off a strong odor of prussic acid, whilst a porous, combustible coal remains.

2. Hippuric acid containing nitrogen, (benzoic acid none,) yields, when heated together with a mixture of soda and lime in a narrow glass tube, ammonia with its characteristic odor, and which blackens paper previously dipped into a solution of proto-nitrate of mercury.

#### ODORIFEROUS AND COLORING MATTERS IN URINE.

The odoriferous substances of urine are as yet very imperfectly known. Staedeler shed the first ray of light upon this subject; he has already traced the following four volatile acids: phenylic,\* taurylic, damaluric, damalic acids. All these he believes to occur ready formed in urine, and to be products of decomposition of animal matter within the organism.†

The coloring matter appears to be a mixture of several bodies, at least two of which have been separated and examined by Scherer; they appear to be destructive products of blood pigment excreted by the passage of the blood through the kidneys.

These pigments, very prone to further decomposition, (plainly exhibited by their variety of changes in healthy and diseased urine,) are rich on carbon, of which they gain still more in arrested functions of the lungs, skin, and liver.

Heller distinguishes three different pigments:

1. Uroxanthine, the ordinary, not yet isolated yellow dye.
2. Urirhodine, a red pigment, probably identical with purpurine, (Bird,) uroerythrine, (Simon,) indigo red, (Berzelius.)
3. Uroglauoine, a blue pigment of the same character as indigo blue, (and probably also identical with cyanurine)

It seems, then, that indigo, which, taken into the stomach, passes into the urine unaltered, is occasionally produced in the organism; it appears to be derived from a substance found in urine which, acted upon by acids, is, according to Schunk, resolved into sugar and indigo blue.

This pigment colors the urine green or bluish green, being deposited sometimes as a green powder; in other cases this blue pigment can only be recognized and precipitated by treating the urine with concentrated nitric or chlorohydric acids, though the urine may be originally of a pale straw color.

\* Syn. with carbolic acid and phenol. A great portion of the kreosote which occurs in commerce is nothing but more or less pure phenylic acid.

† On this subject we would refer to Schlossberger's *Lehrbuch der Organischen Chemie* and Gregory's *Handbook of Org. Chemistry*.

According to Hassall, it occurs most frequently in Bright's disease and pulmonary affections. Neubauer traced it by acids in ordinary-looking urine of an apparently healthy youth, who secreted this pigment for a long time.

It appears that the before-mentioned conjugate sugar compound might in highly acid but normal urine give rise to the presence of sugar.

A rosin-like pigment called omichmyl oxide (Scharling) has lately been discovered in the ethereal extract of urine.

### (B.) INORGANIC CONSTITUENTS.

These remain as ashes, upon evaporation of the urine, and ignition of the residue.

#### CHLORIDE OF SODIUM.

All the chlorine in the urine seems to be combined with sodium, and this chloride is probably mainly derived from our food, of which common salt forms such an all-important part.

Hegar finds the average amount of salt discharged in twenty-four hours = 10.46 grms., (Bischoff = 14.73 grms.;) it attains its max. in the afternoon, sinks to its minim. in the night, increasing again in the morning. The amount of salt excreted varies in different individuals; bodily exercise and indisposition diminish the quantity. Some portion of common salt is eliminated by the lungs in health, and a good deal more in disease, (pneumonia.) Drinking of water increases it at first only. Beer-drinking lessens the quantity extremely.

Different experimenters found that an increased amount of salt consumed, enlarges the elimination of urea.\*

It would hence appear that kitchen salt, whilst furnishing chlorohydric acid for digestion, and soda for the bile, aids also in the metamorphosis of tissue.

In all diseases accompanied by copious exudation from the blood, the amount of salt is greatly lessened; in pneumonia it is present in mere traces, or is entirely wanting. During acute rheumatism, capillary bronchitis, and in typhus, the quantity of chlorides appears diminished.†

Chloride of sodium crystallizes in cubes, frequently assuming, however, when urea is present, the shape of octahedrons and tetrahedrons.

According to Bird,‡ morning urine, when evaporated upon a slip of

\* Gmelin's Handb. (Zoochemie, v. Lehmann,) p. 320.

† Bird, p. 124.

‡ Bird, p. 38. "Urine passed shortly after breakfast is best suited for exhibiting the crystallization of the salts of secretion; it contains less organic matter than any other."

glass, yields crystals of common salt, like crosslets and daggers, variously modified and complicated, and mixed with these are seen dendritic and plumose crystals of phosphate of soda. The determination of chlorine is equivalent to that of salt, hence we recognize the latter by nitrate of silver, throwing down chloride of silver soluble in ammonia, but insoluble in water, even when containing *free* nitric acid. (Distinction from phosphoric acid.)

#### SULPHATES.

The origin of sulphuric acid has partly to be traced to the oxydation of albuminous and fibrinous tissues containing sulphur, and partly to its presence united with bases in the consumed food. An adult discharges about two grms. of sulphuric acid in twenty-four hours; on an average more under animal than vegetable diet; during the act of digestion the amount increases, diminishes at night, and reaches its maximum in the forenoon. Copious draughts of water increase the excretion of sulphates but temporarily, these decreasing subsequently the more. Sulphates taken into the system completely pass off by the urine within eighteen to twenty-four hours. If sulphur be swallowed, the urine gains in sulphates. In disease the sulphates may be increased or decreased. Nitrate of baryta throws down all the sulphuric acid from urine in the presence of free nitric acid.

#### ACID PHOSPHATE OF SODA = $(\text{NaO}, 2 \text{HO},) \text{PO}_5$ .

This salt is very soluble in water, and imparts to it an acid reaction, and is, according to Liebig's experiments, the principal cause of the acidity of urine; and Robin and Verceil state that neutral phosphate  $(2 \text{NaO}, \text{HO}) \text{PO}_5$ , is likewise always present in urine, and may be obtained thus. The fluid from highly concentrated urine is decanted from the saline deposit, when upon the addition of absolute alcohol crystals of the neutral salt are slowly deposited upon the sides of the vessel; these are tables derived from the rectangular or right rhomboidal prisms, with truncation of their edges. Three or four days after the crystallization of the latter salt, there are deposited crystals more transparent and soluble in water—*i. e.*, acid phosphate of soda, the separation of which may be hastened by the addition of ether to the alcoholic liquor above referred to; these crystals seem to be derived from the rectangular or right rhomboidal prism, truncated to the complete obliteration of the whole base. .

Breed states that the quantity of phosphoric acid in urine discharged by different persons within twenty-four hours, amounts to four or five grms. on an average. Beverages at first promote its excretion. At

night more phosphoric acid is excreted than in the morning, and the maximum amount at noon. In disease the quantity of this acid varies considerably, and goes nearly parallel with that of the sulphates.—Heller.

#### EARTHY PHOSPHATES.

Phosphoric acid forms, with lime or magnesia, compounds insoluble in water, but soluble in all acids, even acetic. Hence, in urine containing free acid, or acid salts, we find the earthy phosphates in solution. By neutralizing the urine with a little ammonia, or carbonate of ammonia, the phosphate of lime is at once precipitated in amorphous granules, and the phosphate of magnesia takes up ammonia, giving rise to a deposit of ammonio-magnesian phosphates, appearing in regular crystals.

Hence it will be perceived that neutral or alkaline urine, either fresh (having already fermented in the bladder) or when old, and containing carbonate of ammonia, derived from urea, must of necessity hold earthy phosphates in deposit. Sesquichloride of iron throws down from solutions containing phosphoric acid, even in the presence of free acetic acid, phosphate of iron as a yellowish-white gelatinous mass, soluble in all acids except acetic. Therefore, in order to find out whether urine, from which the phosphates of lime and of magnesia have been removed by ammonia, contains still some phosphoric acid in another form, we add to the filtered liquid, acidulated by acetic acid, sesquichloride of iron.

The emission of sedimentary urine with earthy phosphates (the urine being at times quite milky) is witnessed in affections of the nervous system, mental depression, dyspepsia, injuries of the spine, etc.

#### AMMONIA.

From later experiments by Lehmann, Liebig, and Scherer, it would seem very doubtful whether ammoniacal salts preëxist in normal urine; and where we meet with ammonia in normal acid urine, when concentrated at a low temperature, it is believed to have resulted from the mutual decomposition of pigment and urea, induced by the acid phosphate of soda at this elevated temperature, whereby phosphate of soda and ammonia is formed, already giving off ammonia at 100° C., when acid phosphate of soda is again produced. Upon evaporating or distilling urine, the remaining portion may retain an acid reaction, and still the distilled liquid contain largely ammonia.

#### SULPHIDE OF HYDROGEN (SULPHURETTED HYDROGEN)

Is occasionally met with in urine, and is easily recognized by its odor or its effect upon lead paper. This sulphur, in an unoxymized state, would

seem to have its origin in the metamorphosis of albuminous tissues, a small portion of sulphur being eliminated by the kidneys as sulphur extractive matter.

Taurine, a crystallizable product of decomposition of bile, contains twenty-five per cent. of sulphur, and might be the source of this sulphur found sometimes in urine.

#### IRON.

Traces of this element may in most cases be found in the ashes of urine. If urine contains blood, it becomes more easy to recognize iron in the ashes; in other cases these yield mere traces.

### II. ABNORMAL CONSTITUENTS OF URINE.

#### *Albumen.*

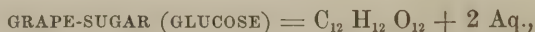
No trace of this body is ever found in normal urine.—Becquerel. It occurs in many acute and chronic diseases, particularly in certain stages, and constantly in degeneration of the structure of the kidneys.

Dr. Hammond found albumen in his urine, after living for seven days exclusively upon coagulated albumen.\*

After verifying its presence by coagulation, it is further recognized thus:

Dilute nitric acid throws it down, but the precipitate is soluble in much water, (an important reëction.) It is also precipitated by corrosive sublimate. Concent. nitric acid colors it yellow upon heating; boiled with conc. chlorohydric acid, (especially by a slight addition of sulphuric acid,) albumen produces a violet liquid.

The most sensitive reëction for albumen (and all other protein bodies, whether dissolved or not) is thus obtained. One part of mercury is dissolved in two parts of nitric acid, (the acid ought to contain  $4\frac{1}{2}$  equiv. of water, as determined by its specific gravity.) This liquor, when heated with a solution of albumen to 60 or 100° C., produces an intensely red mass, which does not vanish either by further boiling or in the air.



We find in urine in diabetes melitus, but not a trace in diabetes insipidus,† (chronic diuresis.)

Brücke,‡ relying upon the facts that liquor potassae or sodae turns

\* Prize Essay of the American Medical Association for 1857, by Dr. W. A. Hammond.

† Tuson in Chem. Gaz., 1859, p. 369.

‡ Nashville Medical Record, Sept., 1859.

urine brown, and, when boiled with sub-nitrate of bismuth and free alkali, reduces (blackens) a portion of bismuth salt, declared healthy urine to contain traces of sugar, whilst others, in repeating his experiments, look to uric acid and its salts as the cause of the reduction, as may be shown by boiling an alkaline solution of sulphate of copper, together with urine containing uric acid and its salts, (with soda and potassa, lime and ammonia.) Brücke, whilst he admits a slight reduction of the copper salts, denies that urine, under the same circumstances, affects sub-nitrate of bismuth. Mialhe, however, proved that even this salt is partially reduced, forming a gray sediment; and *albuminous* urine, according to Grishow, actually blackens it.\* It has before been known that the latter may reduce an alkaline copper solution upon continued boiling.

#### BILE AND ITS COLORING PRINCIPLES.

The bile, usually of an alkaline reëction, may be looked upon as a compound soap. It consists essentially of two salts, the taurocholate and glycocholate of soda, besides of many inorganic salts, (soda, potassa, lime, magnesia, iron, united with sulphuric and phosphoric acids.) It contains further fats, such as cholesterine, and fatty acids in combination with alkali. According to Berzelius and Mulder, the pigment which imparts to bile its brown or green color, is originally but one, which they call biline, but as it is very prone to decomposition, being acted upon by mucus, we find already in the gall-bladder two pigments:

(a.) *Cholepyrrrhine* (*biliphaeine* of Simon) *bilebrown*.

It is very similar to Virchow's haematoidine, and perhaps only a member of a series of alterations of blood-pigment.

(b.) *Biliverdine*, (*bile green*.)

Chloroform constitutes the best means of isolating the two in mixtures, cholepyrrrhine being easily dissolved by it, whilst biliverdine is hardly acted upon; the former can be entirely freed from admixtures of the second by alcohol in which biliverdine is dissolved, but not the cholepyrrrhine. Besides modified pigment, the urine contains, in liver diseases, taurocholic and glycocholic acid, (Strecker's hyocholinic acid.)



This acid, though found in various animal secretions, (gastric juice,

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\* Pathologische Chem. v. Scherer in Canstatt's Jahresb. 1859.

intestines, and sometimes in the blood and saliva,) appears not to occur in normal urine of man, but in that of herbivorous animals.

Lehmann states that he has met with it in those diseases where likewise increased quantities of oxalate of lime can be traced, such as pulmonary emphysema, nervous diseases, rachitis, etc.

During the acid fermentation of urine, lactic acid is formed from an unknown body, probably the extractive (coloring) matter; hence, where we wish to examine for this acid, fresh urine must be used. It is evaporated nearly to dryness in the water-bath, and the residue treated with an alcoholic solution of oxalic acid. The insoluble oxalates, oxalate of urica, etc., remain, and in solution we have lactic acid, besides phosphoric and chlorohydric acids; after digesting with oxide of lead, the lactate of lead alone is dissolved, whilst phosphate and chloride of lead remain behind. In the filtrate the lead is removed by sulphide of hydrogen; the free lactic acid now in solution is boiled with oxide of zinc, the mass subsequently filtered, and some of the liquid suffered to crystallize gradually upon the object-glass, when crystals of lactate of zinc will be recognized by their peculiar club-shaped or barrel-shaped appearance. Vide fig. 15, *b*.

It seems certain that carbo-hydrates, (Liebig's respiratory food,) such as starch, sugar, etc., brought into the organism, are not directly oxydized into the ultimate products, carbonic acid and water, but pass undoubtedly through intermediate changes, of the character of which we know as yet absolutely nothing, and must be satisfied with facts established by chemical experiments in the laboratory.

We learn that saliva, in acting upon starch, produces sugar; this latter can be converted into lactic acid, and finally into butyric acid by ferments. Both these acids are common in the organism; lactic acid abounds in the chyle after digestion of vegetables, and also in the muscular juice even of strictly carnivorous animals; its formation in the former case is easily accounted for—starch and sugar being always contained in vegetables. In the latter case, where it has obviously resulted from protein bodies, it must be the effect of retrogressive metamorphosis.

Carbo-hydrates are oxydized by nitric acid into oxalic acid. Lactates, in the blood as well as by treatment with permanganate of potassa, are quickly turned into carbonates, which, in the last case, however, are mixed with oxalates. Now, since, in spite of these facts, we meet, in pathological conditions, with lactic acid in the blood, and even in the urine, the presence of this acid may be accounted for in two ways, by a large consumption of lactates, or by an incomplete oxydation, of which oxalic acid again must be a product.

## FAT.

The human fat is a mixture of margarate and oleate of glycerine. Fat occurs rarely, and only in traces in urine, but is not necessarily abnormal. The so-called *urina chylosa*, or milky urine, owes its character not to fat, but pus, (Lehmann,) and to excess of phosphates. Cholesterine has been met with in urine, in fatty degeneration of the kidneys.\* In diseases connected with rapid emaciation we meet more frequently with fat globules in urine, when they are readily recognized under the microscope; also by saponification, whereby glycerine is separated, which upon heating produces a strong peculiar odor, (acroleine.) Fat is soluble in ether.

### III. ABNORMAL CONSTITUENTS USUALLY MET WITH AS URINARY SEDIMENTS.

#### 1. These are organized :

##### BLOOD.

Blood is found in urine in inflammation of the kidneys and urinary passages, cancer of the bladder, and in the different stages of Bright's disease, also in paralysis caused by injuries of the spinal column.†

In acid urine the blood corpuscles undergo but little change for a long time, appearing somewhat paler, never adhering in rouleaux. See fig. 1. Other pigments passing into urine may impart to it a red or brown color, such as purpurine,‡ (uroerythrine,) haematoxyline, rhubarb, senna, santonine, etc. The blood pigment, or haematine, is recognized and distinguished thus :

Since all urine containing blood must of necessity be albuminous, we heat a portion to boiling, having previously added a drop of nitric acid; if no coagulum is formed, haematine is absent.

Coagulated albumen, where blood is present, does not look white, but red, turning almost black by drying.

A very sensitive method for tracing blood—especially where haematine has already lost its red color by decomposition, or is masked by bile pigment—has been described by Heller.§

The urine is boiled in a wide *eprouvette*, (a tube bent in shape of a syphon, and sealed on one end,) and then some concentrated liquor potassæ added; the albumen which may have been thrown down is thereby dissolved, the solution turning bottle-green. Heating again for a short time, and agitating the liquid by shaking, the earthy phosphates

\* Hassall in Arch. of Med.

† L. Gmelin's Handbuch, (part Zoochemie by Lehmann,) p. 309.

‡ See Bird, pp. 114, 168, 170, and 284.

§ Canstatt's Jahresbericht, 1859.

are precipitated, and, carrying thus the hæmatinè with them, assume shortly a red or brown color, showing dichroism, (green in reflected light.)

The mass appears, when examined under the microscope, yellow and amorphous. The red color vanishes, however, in a few days, (proceeding from above downwards,) by the effects of the potassa. When not enough phosphates are present to insure precipitation, an equal volume of normal urine ought previously to be added.

The urine tinged red with purpurine is not affected in color or transparency by boiling; where purpurine, which usually colours urates, occurs as sediment, it differs from hæmatine in this, that the sediment when boiled with water is dissolved, assuming a yellow color; sugar of lead added to the clear liquid again throws down a pink precipitate.

Alkaline urine when colored blood-red by hæmatoxyline, rheum, or senna, turns yellow, by slightly acidulating it; such urine does not coagulate, and free alkali again restores the original red color; hence, in acid urine, these pigments, if present, but little heighten its color. These same dyes may occur in sediments and coloring phosphates.

For the distinction of bile pigment from blood, see § 4.

#### PUS.

The microscope alone can assist us in recognizing purulent matter; it occurs in round vesicles, granulated upon their surface, which exceed in size the blood corpuscles. When pus cells are treated with acetic acid, they grow larger, lose their granulated appearance, and the cell-membranes become very thin, discharging the contained nuclei as they burst. See fig. 24.

Pus is not unfrequently found in urine in suppuration of the kidneys or some portion of the mucous membrane covering the genito-urinary system. The urine containing pus is generally acid, the purulent matter forming a dense cream-colored sediment which is never ropy. In alkaline (putrid) urine containing ammonia, pus appears completely altered, becomes viscid, resembles mucus, or may be mistaken for phosphates.

#### CYLINDRICAL MASSES OR CASTS.

These occur in the urine during the various stages of Bright's disease. Lehmann divides them according to their structure into three kinds.\*

1st. Epithelial casts consist of elongated pieces of the epithelial lining of the renal (Bellini's) tubes, the surfaces of which are studded with little

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\* Gmelin's Handbuch Zoochemie, by Lehmann, p. 308. Compare also G. Bird, pp. 280, 281.

cells containing nuclei and granular matter, grouped like honeycomb. These casts are indicative of the acute stage of Bright's disease, or desquamative nephritis. Compare fig. 23.

2d. Hyaline or structureless casts. These form hollow, scarcely recognizable cylinders, with extremely transparent walls, which frequently falling in, give rise to folds, when the cylinders look as if they were twisted around their axis. These occur in the chronic form of Bright's disease. See fig. 22.

Some portions of the figure are rendered more visible, being filled with minute granules of urate of soda.

3d. Granular casts, consisting of coagulated fibrine, secreted within the cavities of the tubuli of Bellini, and maintaining thus their shape. They enclose generally pus and blood-cells. Acted upon by liquor potassæ or sodæ, these cylinders are dissolved, (a proof of being coagulated fibrine,) and the enclosed blood and pus globules are partially destroyed, or remain suspended in the liquid.

These casts always appear in urine in Bright's disease, (Frerichs.) See fig. 21.

#### SPERMATOOZA.

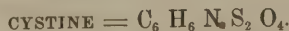
These are found in urine, after emissions; in typhus fever or in spermatorrhœa. The spermatozoa form minute ovate bodies, provided with a delicate tail. See fig. 20.

#### MUCUS.

This consists of epithelial cells coming from the mucous membrane of the bladder. In healthy urine the quantity of mucus is very small, settling down as a scarcely perceptible cloud, increasing much in irritative, inflammatory disease, giving rise to a viscid deposit. It shows the chemical deportment of albumen, is coagulated by boiling, nitric acid coloring it yellow. The action of acetic acid is important in discriminating between mucus and pus. This acid coagulates mucus into a thin translucent corrugated membrane. Agitated with ether, mucus gives up mere traces of fat, whilst pus, when extracted thus, yields upon evaporation in a watch-glass, yellow fat globules.

Mucus, consisting of rows of closely connected cells, is often found in urine after gonorrhœa, in *goutte militaire*, and most frequently in diseases of the prostate glands. See fig. 11.

#### 2. *Sediments not organized.*



This substance, first discovered in urinary calculi, has been occasion-

ally found in abnormal urine, either in solution (from which it may be precipitated by acetic acid) or in the form of a sediment, mixed with urate of soda. It contains twenty-six per cent. of sulphur, and appears under the microscope as six-sided transparent plates or prisms, insoluble in boiling water and acetic acid. From earthy phosphates and urates it can be separated easily by boiling, or treatment with acetic acid. From uric acid which occasionally crystallizes in similar forms, it is characterized by the murexide reaction, cystine giving under the same circumstances a brown color. Cystine boiled with liquor potassæ, containing some oxide of lead in solution, yields dark sulphide of lead.

#### OXALATE OF LIME.

Oxalic acid, though of common occurrence in the vegetable kingdom, is found rarely, and only in extremely small quantities, in the healthy urine of man, and always united with lime. The oxalate of lime crystallizes in square octahedrons, rarely assuming the shape of dumbbells,\* a form in which uric acid is deposited.

According to Bird,† oxalate of lime occurs in minute portions, even more frequently in sediments than earthy phosphates. He looks upon this salt as the common result of destructive metamorphosis, but regards its presence as strictly pathological where we meet it in considerable quantities, and in large crystals, as in nervous debility, hypochondria, epilepsy, icterus, or dyspepsia; in convalescence from typhus fever, rachitis, heart diseases, also in disturbed respiration, or emphysema of the lungs. Its amount is also increased by vegetable diet, the use of sparkling drinks, (wine, beer,) lemon-juice, an excess of sweets, and after taking into the system bicarbonates of the alkalies, or salts of the same bases united with organic acids;‡ finally, when we partake of rich nitrogenous food with want of exercise. Thus we observe oxalate together with carbonate of lime in the urine of carnivora. It seems that even fresh urine as it comes from the bladder may contain oxalate of lime in solution, as proved by Lehmann. He evaporated previously filtered urine to dryness, extracted the residue with concentrated alcohol, and shaking the extract with ether, precipitated oxalate of lime in beautiful octahedrons; indeed, Neubauer proved by experiment that considerable quantities of oxalate of lime may be dissolved by phosphoric acid, and

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\* These crystals are perhaps oxalurate of lime, or contain some other acid easily convertible into oxalic acid. Consult G. Bird, pp. 195-199.

† Ibid., p. 191.

‡ Gmelin's Handbuch, (Zoochemie,) p. 313.

that solutions of urate of soda and phosphate of soda produce the same effect.\*

#### URIC ACID AND URATES.

Uric acid in sedimentary form is found only in strongly acid urine, accompanied by acid urates, especially acid urate of soda. This acid is always more or less colored, varying from yellow to brown. See figs. 11 and 19.

The urates, with exception of urate of ammonia, are deposited only from acid urine. The urate of soda appears amorphous, in fine granules, separate or in irregular heaps. See figs. 8, 11, and 19. Bird considers this salt yet to be urate of ammonia.

Urate of soda, together with traces of urates of lime and of ammonia, separate from urine where the quantity of its normal salts are increased, from the same causes as augment the uric acid, normally when the exchange of gases in the lungs is interrupted, or when the normal amount of blood is not carried into the lungs. Hence these sediments are observed in the urine of man and of animals when exercise is insufficient, (prisons, menageries.)

Acid urate of ammonia is usually found only in alkaline urine which has fermented on the air, or where, as in spinal diseases, the bladder is paralyzed. This salt appears under the microscope as dark globules, provided with bristle-like appendages. See figs. 16 and 18.

#### EARTHY PHOSPHATES.

In phosphatic sediments we find almost always both phosphate of lime and ammonio-phosphate of magnesia. Owing to their solubility even in weak acids, they can occur only in neutral or alkaline urine. The lime-salt forms an amorphous powder, refracting light powerfully.

The ammonio-magnesia salt crystallizes in regular, beautiful crystals.

Where urates and phosphates are mixed, as in deposits of alkaline urine sometimes, we trace each peculiar form of salt by bringing a few drops of urine between two glass plates under the microscope; besides, urates are readily soluble in hot water, (separating again on cooling,) whilst phosphates are not affected. Urates give the already described murexide reaction.

If oxalate of lime should also be present, we distinguish where the form of crystals leaves in doubt, by adding some acetic acid, which readily dissolves phosphates, but does not the oxalate.

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\* Ann. d. Chem. u. Pharm., lx., p. 55.

### 3. *Accidental constituents.*

The importance of investigating the alterations which substances, taken into the system, undergo by their passage into the urine, is obvious, as we become thus enabled to get a clear insight into the mechanism of our organism. As a matter of course, only such substances pass unchanged through the body into the urine which,

1st. Do not serve as food.

2d. Are soluble in water, and not inclined to enter with the organic or inorganic material of our system into insoluble combinations.

Hence most of the salts with alkaline bases (saltpetre, etc.) are found again as such in the urine.

Compounds which easily take up oxygen present themselves in the urine in an oxydized form; thus sulphide of sodium =  $\text{Na S}$  passes into the urine as sulphate of soda =  $\text{Na O, SO}_3$ .

Those bodies which, like, for instance, most metals, can unite with protein in the animal body, are found in the urine then only, when large quantities have been administered. (Orfila.) It appears that most of the heavy metals, such as copper, zinc, cadmium, etc., are excreted from the blood principally by the liver, as only traces appear in the urine.\*

Mosler† found sulphate of copper in the urine of an animal after giving repeated doses; whilst ten-gramme doses of saltpetre being administered, none of this salt could be traced in the liver.

Many organic bodies in travelling through our body undergo the same variations which can be produced in the laboratory; others, again, lose oxygen, and appear as lower oxides in the urine; whilst a third class is completely oxydized, and none of its products of destruction are found in the urine. The idiosyncrasy of a person seems likewise to affect the urinary excretion even of very soluble substances. Thus Lehmann found that after administering ten grains of iodide of potassium, the urine of some persons contained, after twenty-four hours, no more of this salt, whilst in other cases it took three days to remove every trace of it from the system by this passage.

The kidneys acting as blood-depurants, are ever ready to remove from the circulation injurious (poisonous) matters,‡ and how often is the crisis

\* Buchheim's *Arzneimittellehre*, p. 287.

† Mosler found that mercury, at least in the form of calomel, does not pass as rapidly into the bile, nor does it increase its secretion in such a measure as is generally assumed in practical medicine. (*Canst. Jahresb.*, 1859.)

‡ Whence, in medico-legal investigations, the kidney and bladder should always be examined as well as the stomach.

of a disease, such as fever, indicated by a change of the urine. It is believed that many physicians as yet neglect too much, if not altogether, the examination of this fluid constituting the main sewage of the system.

We will now somewhat specify the individual changes which some bodies undergo in the system. This forms a subject to which the celebrated Wöhler has lately turned his attention.

1. The alkaline carbonates appear in urine again as such, rendering the urine neutral or alkaline. A portion of these will of course combine with the free acid in the stomach.

2. Organic acids: oxalic, malic, citric, succinic, tartaric, gallic acids, when consumed in a free state, pass into the urine unaltered.

3. The neutral salts of these same acids appear as carbonates.

4. Urea undergoes no alteration.

5. Uric acid furnishes the urine with urea and oxalic acid, (allantoine?) Neubauer could readily trace crystals of oxalate of lime in his morning urine, when swallowing, the evening previous, three-fourths of a gramme of urate of ammonia.

6. Iodine appears in the urine as iodide of sodium.

7. Soluble salts of baryta (poisonous) underwent no change.

8. Ferrieyanide of potassium is reduced to ferrocyanide of potassium.

9. Ammonia and its salts pass into the urine mostly without change.

10. Rhodizonate of potassa, even in small quantities, may soon be traced in the urine.

11. Tannic acid appears as gallic acid.

12. Benzoic acid is transformed into hippuric acid; indeed, this forms the best way to prepare larger quantities of the latter.

13. Quinine is easily recognized as such if the doses taken are not too small.

14. Theine (caffeine) and theobromine cannot again be detected in urine.

15. Aniline—same result.

16. Alloxantine appears to yield urea, etc.

17. Amygdaline could not again be traced with certainty in urine; the latter contained, however, formic acid, (Lehmann and Ranke.)

18. Salicine undergoes the same changes as when oxydized; the urine contains hyduret of salicyl syn. salicylous acid—(*i. e.*, the essential oil of meadow sweet or *spiræa ulmaria*,) further salicylic acid and saligenine, but no sugar and phenylic acid could be found.

19. The volatile oil of bitter almonds (is not poisonous when free of prussic acid) forms hippuric acid.

20. Most coloring and odoriferous principles pass into the urine unaltered, or but little modified.

Thus Wöhler found again the following substances: indigo, madder, gummigutti, rhubarb, logwood, carrots, whortle-berries, (*vaccinium*.) Further, the odoriferous matter of valerian, garlic, assafœtida, castoreum, saffron, spir. turpentine, but could not again recognize in urine, rosins, camphor, empyreumatic oil, musk, alcohol, ether, cochineal, litmus, sap-color, alkanet.

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#### SYSTEMATIC COURSE FOR THE QUALITATIVE EXAMINATION OF URINE.

The urine chosen for examination should be passed into a suitable glass vessel, immediately after rising from bed, the vessel kept closed air-tight, and the contents tested as soon as practicable.

##### *Division A.*

§ 1. We examine the urine with litmus paper.

a. It tests acid, and shows no sediment: pass over to § 2.

b. It is acid and turbid, or contains a sediment; let it subside, decant the clear liquid, (or filter if necessary,) and examine according to § 2. The sediment is examined microscopically, (*vide* Division B.)

c. The urine reacts neutral or alkaline. In this case it exhibits generally a sediment; this is examined as directed in B, and the filtered urine according to § 2.

§ 2. A small quantity of urine is acidulated with a trace of acetic acid, (if not previously reacting acid,) and heated to ebullition; if a coagulum is produced, which does not disappear by the addition of a drop of nitric acid, albumen is present.

A considerable quantity of urine (100 cubic centimetres =  $\frac{1}{2}$  litre = 1 wine pint) is heated to boiling, the coagulum filtered off, the liquor tested according to § 3. The coagulum, if it appears:

a. White; is pure albumen.

b. Greenish to brown; contains bile. In this case the urine is more or less tinged at first, and froths like soap when shaken, (§ 4.)

c. Reddish-brown. We examine for blood; if present, the microscope will reveal corpuscles in their normal shape, or irregular at their margins, (fig. 1.)

Even if the corpuscles should be entirely destroyed, we may trace the blood thus: The reddish-brown coagulum above-mentioned (c) is dried, (it appears then nearly black,) pulverized, and extracted with alcohol, which was previously mixed with a little sulphuric acid. The filtered liquid is of a red or brown color, provided blood (*hæmatine*) be present.

Evaporating this liquid again, and igniting the residue, the ashes left contain iron, which is recognized readily thus: We dissolve in dilute chlorohydric acid, treat the solution with a drop of nitric acid, and heat to boiling; when sulpho-cyanide of potassium imparts a red color, whilst ferro-cyanide of potassium (the solution should first be more diluted with water) throws down sparingly a blue precipitate. For Heller's new test, see p. 17.

§ 3. Some sixty cubic centimetres of clear acid urine, or such as has been separated from the coagulated albumen, are evaporated to syrupy consistency in a water-bath, and the mass extracted with alcohol. The soluble portion is now filtered, whilst the insoluble part, after being repeatedly washed by decantation with alcohol, is left in the evaporating dish for further examination.

The solution is tested thus:

*a.* One-third of it is evaporated nearly to dryness in a water-bath, and then examined for urea. Pure nitric acid, of medium strength, produces a rapid formation of white plumose crystals or scales, consisting of nitrate of urea; hence, by mixing a drop of each liquid together under the microscope, rhombic octahedrons or hexagonal plates will be observed, (fig. 2.)

The crystals of oxalate of urea formed under the same circumstances are similar in shape, (fig. 3.)

*b.* The other two-thirds of the same solution are mixed with oxalic acid, the whole evaporated nearly to dryness, and the residue left is extracted with ether containing about one-sixth part of alcohol, and the solution evaporated to dryness, the mass digested with a few drops of water, heat applied, the solution filtered, and then left on a watch-glass to spontaneous evaporation, when crystals of hippuric acid appear, (fig. 4.) For its chemical tests, see p. 9.

Should the urine contain fat, it will remain on the filter when the ethereal residue in *b* is treated with water, and filtered.

*c.* The insoluble residue left in the dish (§ 3) is treated with dilute chlorohydric acid, (one part of acid and six parts of water,) and the insoluble part separated by filtering.

*aa.* This acid solution contains phosphates of the earths and other salts; the former are precipitated by neutralizing the liquid with some ammonia.

*bb.* The residue on the filter (§ 3, *c*) contains mucus and uric acid; after washing it sufficiently, the filter is pierced with a glass rod, and the contents washed into a reagent tube, some drops of caustic soda added, heat applied, and the solution filtered off; the insoluble portion is mucus;

the filtrate contains uric acid, which, by the addition of a little chlorohydric acid, falls in a crystalline form. When examined under the microscope, we observe rhomboidal plates, and sometimes compound crystals shaped like dumb-bells, (figs. 5, 14, and 19.)

A portion of the crystals may be tested chemically, to confirm the presence of uric acid. We dissolve them in nitric acid; evaporate, with caution, to dryness; what remains is moistened with a trace of ammonia, (or merely exposed to its vapor,) when a deep purple mass is produced by gentle heating, which, on cooling, deposits gold-green crystals of murexide.

cc. If it is desirable to examine for lactic acid, we treat the alcoholic extract, prepared according to § 3, as directed under lactic acid, p. 16.

§ 4. Should the urine appear colored brown or green, and be frothy, we have reason to suspect bile, or its pigments, cholepyrrhine or biliverdine. A small quantity of urine is poured on a white plate, and a drop of red (fuming) nitric acid allowed to fall on it, when, if cholepyrrhine be present, a play of colors appears, passing from green, blue, violet-red, finally into yellow. A mixture of equal portions of nitric and sulphuric acids renders frequently the reaction still more distinct.

If we fail to find cholepyrrhine, we test next for biliverdine. Some urine is treated with a solution of sub-acetate of lead; a colored deposit falls, which is collected on a filter, washed, and dried. The mass, having been removed from the filter, is digested with some alcohol containing a few drops of sulphuric acid; the mixture shaken, and then left to subside. If the alcohol assumes a green color, biliverdine is indicated. For further confirmation, we mix another quantity of urine with some soluble albumen, and add nitric acid until coagulation takes place; a bluish-green deposit is formed should biliverdine be present.

If no coloring matter of bile can be detected, we turn our attention to glyco-cholic and tauro-cholic acid, (united with soda in the bile,) which have been occasionally met with in morbid urine. A portion of urine is evaporated almost to dryness, in a water-bath, the residue treated with alcohol, the alcoholic extract again boiled down, and what remains, dissolved in a small quantity of water. This solution, brought into a test-tube, is mixed with a few drops of sugar solution, (one part of sugar and four parts of pure concentrated sulphuric acid.) It will turn purple, if either of the acids named be present. The trial can be made with the original urine, provided it is free from albumen, which, as it shows a similar deportment, has always first to be removed.

§ 5. The urine is examined for sugar.

1. Add to the suspected urine, previously brought into a long test-

tube, just enough of a solution of sulphate of copper to tinge it slightly blue, (a slight deposit of phosphate of copper generally falls, which may or may not be filtered off,) and, after that, liquor of caustic soda or potassa in great excess. A blue precipitate of hydrated-oxide of copper is at first thrown down, which is re-dissolved in the excess of alkali. On gently heating the solution to ebullition, a red sediment of sub-oxide of copper falls, if sugar be present.

2. Or we mix with an alkaline solution of sulphate of copper (being previously diluted) some twenty to thirty drops of urine, and apply a gentle heat.

In regard to these tests (§ 5, 1, and 2) it may not be superfluous to remark that albuminous matter may (especially by continued boiling) cause likewise a reduction in the alkaline copper solution; indeed, it was recently observed that the mucus of normal urine, or the mucus of the vagina discharged with the urine, particularly of pregnant and parturient females, induces the same changes readily, giving thereby cause to mistakes and erroneous results in the qualitative and quantitative determination of sugar. Of course, in such cases, it becomes an absolute necessity, first to get rid of the mucus before testing for sugar.

A certain quantity of such urine is evaporated upon a water-bath to dryness, and the remainder extracted by strong alcohol, which dissolves, besides urea, all the grape-sugar present. This solution may be divided into two parts. From one portion we drive off the alcohol in the water-bath, whence the residue is brought directly in contact with the alkaline copper solution; to the second portion of the liquid we may add a solution of caustic potash, in absolute alcohol, when all the sugar is thrown down in the form of an insoluble potassa-saccharate. This precipitate, first dissolved in a little water, we bring now together with the alkaline copper solution. The least trace of glucose is thus unmistakably traced in any urine, whether normal or abnormal. The same precautions will apply to test 4, mentioned below.

3. Bring into a narrow test-tube some two cubic centimetres (or two drachms) of urine, and add to it about half its bulk of caustic soda or potassa, and heat the upper part of the tube over a lamp to boiling. That portion of the liquid exposed to the alcohol flame will turn brown if sugar is present.

4. Some urine is brought into a test-tube, a small piece of caustic potassa added, and subsequently a small amount of basic nitrate of bismuth, (*magisterium bismuthi*.) The whole is now slowly heated to boiling, when a gray or dark deposit, consisting of reduced bismuth, subsides if sugar was present. In some cases it becomes necessary to prove

the absence of sulphur which would precipitate dark sulphide of bismuth, (test as directed, § 8;) compare also p. 15 as to the effects of uric acid and albumen upon the bismuth and copper reactions.

5. To a solution of indigo in sulphuric acid, add an excess of carbonate of potassa or soda, then pour a very little of this mixture into the urine to be tested. If sugar be present, the blue color of the indigo will disappear, especially upon boiling, but turn blue again on the air after a while.

6. The addition of a little pure bile to diabetic urine, followed by that of concentrated sulphuric acid, produces a transient purple color.

7. *Fermentation test.*—Fill a test-tube with the diabetic urine, and add a little brewers' yeast diluted with water, until the tube is full to overflowing, then close it with the thumb, invert it, and place it, without admitting air, into a saucer containing some of the same urine. If sugar be present, gas bubbles will soon occupy the upper part of the tube.

8. The presence of yeast-fungi formed in spontaneously fermenting urine is an additional evidence that saccharine matter is in the urine. Some yeast-cells, exhibiting their mode of propagation, *i. e.*, by budding, are seen in figs. 8 and 11.

§ 6. A quantity of urine is mixed with half its bulk of concentrated chlorohydric acid: should it turn dark, and deposit a blue powder, cyanurine (indigo) is present.

§ 7. Kreatine and kreatinine are found in small quantities in urine: for their separation, we refer to p. 8. In regard to their crystalline character, consult fig. 6, for kreatine; and fig. 7 for kreatinine.

§ 8. If urine emits an odor of rotten eggs, or turns paper—previously dipped into a solution of acetate of lead—brown or black, sulphide of hydrogen is present.

§ 9. In order to analyze urine for its inorganic constituents, we evaporate some ten to twenty cubic centimetres of this liquid; the dry mass left is mixed with one to two grains of platinum sponge, and slowly ignited, until all the carbon is burned off; the rest, or the ashes, is boiled with water; the whole is thrown upon a filter, and the liquid passing through is then examined as follows:

*a.* We acidulate a small quantity with chlorohydric acid, and add chloride of barium: a white precipitate shows sulphuric acid.

*b.* Another part, first rendered acid with nitric acid, is mixed with nitrate of silver, when a white, curdy, mass falls, should chlorine be present.

*c.* To a third portion we add acetate of soda, then some acetic acid, and finally a drop of sesquichloride of iron: if a yellowish-white gelatinous precipitate is deposited, phosphoric acid is indicated.

*d.* The rest of the aqueous solution is evaporated to complete dryness,

and a portion examined before the blowpipe: if soda be present, the exterior blowpipe flame appears of an intensely yellow color.

*e.* Another part of the salt obtained in *d* is dissolved in a few drops of water, and mixed with a few drops of chloride of platinum: if it contains potassa, a yellow crystalline precipitate will be formed.

Should the aqueous extract of the ashes contain also lime and magnesia, (the former is recognized by oxalate of ammonia, the latter by phosphate of soda with ammonia,) both of these have to be removed before we can test for the alkalies. To this end, we precipitate the lime by oxalate of ammonia, separate by filtering, evaporate the filtrate entirely, and ignite the residue in order to drive off the ammoniacal salts, and dissolve again in water, and add to the solution baryta-water, until an alkaline reaction takes place; the magnesia which is thus precipitated is filtered off. The excess of baryta is now separated by the addition of ammonia and carbonate of ammonia, and the filtrate again evaporated to dryness. With the residue remaining, (consisting of the alkalies,) we proceed as stated above, (§ 9, *d* and *e.*)

In most cases, however, the aqueous extract tests alkaline, and contains none of the alkaline earths.

§ 10. The residue, insoluble in water, (§ 9,) is heated with some chlorohydric acid, the whole brought upon a filter, and, after washing the remainder on the filter, the acid solution is tested thus:

*a.* One portion is boiled with a drop of nitric acid, and afterwards some sulpho-cyanide of potassium added: if the mixture turns red, iron is present.

*b.* The remaining quantity is treated with an excess of acetate of soda, and, with oxalate of ammonia, tested for lime.

*c.* After all the lime has been precipitated, and removed by filtration, we add ammonia: if the liquid contains magnesia, a white crystalline powder, consisting of phosphate of magnesia and ammonia, falls.

Most of the examinations mentioned in §§ 9 and 10 could be carried on with the original urine, (filtered, if necessary,) but the reactions made with the ashes themselves are more distinct.

#### EXAMINATION OF URINARY SEDIMENTS UNDER THE MICROSCOPE.

We ought to know whether the urine is fresh, or whether it has undergone some changes, induced by fermentation, etc.

##### *Division B.*

We test the urine first with litmus-paper, bring it into an air-tight

glass vessel, and suffer the sediment to subside completely; the liquid above it is carefully decanted, and analyzed according to § 2.

A. The urine is acid.

1. The whole sediment is amorphous.

a. A drop of it is gently heated on the object-glass: if complete solution takes place, urates are present.

To have further proof, we add, after cooling, one drop of chlorohydric acid; after the lapse of fifteen to twenty minutes, we bring the slip of glass under the microscope: if uric acid is present, it appears in rhomboidal plates, (see fig. 5.)

In most cases, the amorphous mass consists of acid urate of soda, (figs. 8, 11, and 19.)

b. If the sediment does not dissolve when heated, but is soluble, without effervescence, in acetic acid, phosphate of lime is present. It is precipitated by alkalies, as an amorphous powder.

c. The sediment exhibits particles of a silvery lustre, soluble in ether: fat is present.

2. The sediment shows regular crystals.

a. They consist of minute transparent octahedrons, which are insoluble in acetic acid. Oxalate of lime is present. In many cases, the crystals of this salt accumulate, and form bundles like fig. 9.

Dumb-bell crystals, consisting of carbonate of lime, (obtained from the urine of a rabbit,) are seen in fig. 15, a.

b. The crystals are prismatic, lozenge-shaped, or rhomboidal, often more or less colored, and consist of uric acid, (figs. 5, 14, and 19.)

Should some doubt be left, we dissolve them on the object-glass, in a drop of caustic soda, adding subsequently a drop of chlorohydric acid, and examine these new forms microscopically; also, chemically, if necessary, (formation of murexide.)

c. Hexagonal plates, like those in fig. 10, which are soluble in chlorohydric acid and in ammonia, and carbonize and burn, if ignited, consist of cystine. This substance may be further recognized by its giving rise to the formation of dark sulphide of lead, when mixed with a solution of oxide of lead in caustic soda.

3. The sediment consists of organized matter.

a. Coiled, cylindrical masses, made up of little dots and granules formed of coagulated mucus, accompanied by urate of soda and yeast fungi, are seen in fig. 11.

These coils must not be confounded with the *tubuli uriniferi*, mentioned in e, with which they have some resemblance.

b. Minute, strongly contracted, and granulated particles, mostly united

by their margins to one another, forming peculiarly shaped groups. Are mucus cells, (figs. 12 and 17.)

c. Circular, bi-concave discs, (emptied of their contents by exosmosis,) are blood corpuscles: they are generally feebly colored. Acetic acid causes them first to swell up, and, sooner or later, to disappear. (See fig. 1.)

d. Pale-looking and granulated globules, larger and less transparent than blood discs, which, by the action of acetic acid, are caused to swell up, exhibiting distinctly their variously shaped nuclei, consist of pus, (fig. 24.)

e. The sediment contains colorless casts, of cylindrical shape, entangling blood and pus cells, which are frequently found together with epithelial scales and mucus. Compare p. 18. Their characteristic shape is shown in figs. 21, 22, and 23.

f. Spermatozoa: consisting of an ovate body, with a delicate, bristle-like tail; are easily recognized, (fig. 20.)

g. Confervæ and yeast fungi, in different stages of development, are found in fig. 13, and yeast-cells, together with urate of soda, uric acid and oxalate of lime, as they occur in fermenting urine, particularly in diabetic, are seen in fig. 19.

#### B. The urine tests alkaline.

1. The sediment contains crystals in rhombic prisms, with a variety of terminations, and exhibiting remarkably perfect angles and edges. These characteristic forms of triple phosphate of ammonia and magnesia are represented in fig. 16, together with urate of ammonia; in fig. 17, together with mucus; and in fig. 18, in connection with urate of ammonia, (a rare form,) seen occasionally in old, decomposed urine.

This salt is soluble in acetic acid, and when heated together with a drop of liquor potassæ, yields ammonia.

Should oxalate of lime, in the previously described form, be also present, we pour a drop of acetic acid on the object-glass, when the triple phosphate is dissolved, but not the oxalate.

Minute opaque and club-shaped bodies, adhering together, and forming stellate masses, indicate urate of ammonia, (fig. 18.) This salt also occurs in conglomerate globules, provided with projecting and generally curved processes, (fig. 16.)

2. The sediment is amorphous, and, in alkaline urine, ordinarily consists of phosphate of lime.

3. The sediment contains a variety of organized bodies. Besides the constituents enumerated in Division A, we find numerous fungi, confervæ, infusoria, etc.

